DACA42-03-C-0024

LOGANEnergy Corp.

GA Tech ROTC PEM Project
Georgia Institute of Technology, Atlanta, Georgia
Final Report

Proton Exchange Membrane (PEM) Fuel Cell Demonstration
Of Domestically Produced PEM Fuel Cells in Military Facilities

US Army Corps of Engineers
Engineer Research and Development Center
Construction Engineering Research Laboratory
Broad Agency Announcement CERL-BAA-FY02

Georgia Tech ROTC Headquarters
Atlanta, Georgia

July 27, 2006

Executive Summary

In October 2001 LOGANEnergy contacted Dr. David Parekh, assistant Director of the Georgia Institute of Technology Research Institute (GTRI), to propose partnering a DOD Proton Exchange Membrane (PEM) fuel cell demonstration at the Air Force ROTC building at Georgia Institute of Technology (GA Tech). Dr. Parekh responded positively and the project was set in motion.

In August 2003, the site was approved as an amendment to LOGAN's FY02 contract, DACA42-03-C-0024. In early December 2003, LOGAN representatives met with Colonel Terry McCarthy and Dr. David Parekh for the project kickoff meeting. Dr. Mike Binder represented US Army CERL. In mid January 2004, the unit was delivered to GA Tech in preparation for installation. However, due to administrative difficulties described in the body of the report, the installation process took over a year to complete. The official start date occurred in early February 2005. The project concluded in March 2005 having achieved 96% operational availability. Georgia Power was the electric service provider and Atlanta Gas Light provided natural gas fro the project.

The Point of Contact for this site was Colonel Terry McCarthy, GA Tech Air Force ROTC commander who may be reached at (404) 894-4175 or via email at terrance.mccarthy@rotc.gatech.edu. The point of contact for the Georgia Tech Research Institute was Dr. David Parekh. He may be reached at 404.894.7136 or via email at david.parekh@gtri.gatech.edu . Due to the exceptionally low cost of metered electricity provided by Georgia Power, the fuel cell project was not able to compete with the grid on a financial basis. Furthermore, since thermal recovery at the ROTC site was extremely low, GA Tech paid an energy premium of $615.00 to host this demonstration project.

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Proposal – Proton Exchange Membrane (PEM) Fuel Cell Demonstration of Domestically Produced Residential PEM Fuel Cells in Military Facilities

1.0 Descriptive Title

GA Tech Air Force ROTC Detachment 165 Headquarters Building, Atlanta, Georgia PEM Demonstration Project.

2.0 Name, Address and Related Company Information

LOGANEnergy Corporation

1080 Holcomb Bridge Road
BLDG 100- 175
Roswell, GA 30076
(770) 650- 6388

DUNS 01-562-6211
CAGE Code 09QC3
TIN 58-2292769

LOGANEnergy Corporation is a private Fuel Cell Energy Services company founded in 1994. LOGAN specializes in planning, developing, and maintaining fuel cell projects. In addition, the company works closely with manufacturers to implement their product commercialization strategies. Over the past decade, LOGAN has analyzed hundreds of fuel cell applications. The company has acquired technical skills and expertise by designing, installing and operating over 30 commercial and small-scale fuel cell projects totaling over 7 megawatts of power. These services have been provided to the Department of Defense, fuel cell manufacturers, utilities, and other commercial customers. Presently, LOGAN supports 40 Phosphoric Acid Fuel Cells (PAFC) and PEM fuel cell projects at 21 locations in 12 states, and has agreements to install 22 new projects in the US and the UK over the next 18 months.

3.0 Production Capability of the Manufacturer

Plug Power manufactures a line of PEM fuel cell products at its production facility in Latham, NY. The facility produces three lines of PEM products including the 5kW GenSys5C natural gas unit, the GenSys5P Liquid Propane Gas (LPG) unit, and the GenCor 5kW standby power system. The current facility has the capability of manufacturing 10,000 units annually. Plug Power will support this project by providing remote monitoring, telephonic field support, overnight parts supply, and customer support. These services are intended to enhance the reliability and performance of the unit and achieve the highest possible customer satisfaction. Vinny Cassala is the Plug Power point of contact for this project. His phone number is 518.782.7700 ex1228, and his email address is vincent_cassala@plugpower.com.

4.0 Principal Investigator(s)

Name	Samuel Logan, Jr.	Keith Spitznagel
Title	President	Vice President Market Engagement
Company	Logan Energy Corp.	Logan Energy Corp.
Phone	770.650.6388 x 101	860.210.8050
Fax	770.650.7317	770.650.7317
Email	samlogan@loganenergy.com	kspitznagel@loganenergy.com

5.0 Authorized Negotiator(s)

Name	Samuel Logan, Jr.	Keith Spitznagel
Title	President	Vice President Market Engagement
Company	Logan Energy Corp.	Logan Energy Corp.
Phone	770.650.6388 x 101	860.210.8050
Fax	770.650.7317	770.650.7317
Email	samlogan@loganenergy.com	kspitznagel@loganenergy.com

6.0 Past Relevant Performance Information

a) Contract: PC25 Fuel Cell Service and Maintenance Contract #X1237022

Merck & Company
Ms. Stephanie Chapman
Merck & Company
Bldg 53 Northside
Linden Ave. Gate
Linden, NJ 07036
(732) 594-1686

In November 2002 Merck & Company issued a four-year contract to LOGAN to provide fuel cell service, maintenance and operational support for one PC25C fuel cell installed at their Rahway, NJ plant. During the contract period the power plant has operated at 94% availability. LOGAN performs the quarterly and annual service prescribed by the UTC, and performs other maintenance as required. The periods of unavailability are chiefly due to persistent inverter problems that seem to be endemic to the Toshiba power conditioning balance of the system. Field modifications and operating adjustments have largely cured the problem. Quarterly service events take 10 hours to complete with the unit under load, and the annual event takes approximately 35 hours with the unit shut down.

b) Contract: Plug Power Service and Maintenance Agreement to support one 5kWe GenSys 5C and one 5kWe GenSys 5P PEM power plant at NAS Patuxant River, MD.

Plug Power
Mr. Vinny Cassala
968 Albany Shaker Rd.
Latham, NY 12110

(518) 782-7700 ex. 1228

LOGAN performed the start-up of both units after Southern Maryland Electric Cooperative completed most of the installation work. The units are located at residential sites at Patuxant River Naval Air Station, MD and operate in standard gird connected/grid independent configurations. Both operate at 4.5kWe and have maintained 98% availability. The units, S/Ns 241 and 242 are two of the very latest GenSys models to reach the field. S/N 242 is Plug Power's first LPG fueled system to go into the field. Both have set new performance standards, and raised expectations for near term commercial viability for this product. Operations to date are indicative of the success of the various test and evaluation programs that have been conducted over the past two years.

c) Contract: A Partners LLC; Commercial PC25 Fuel Cell Project Design, Installation and 5-year service and maintenance agreement.

Mr. Ron Allison
A Partners LLC
1171 Fulton Mall
Fresno, CA 93721
(559) 233-3262

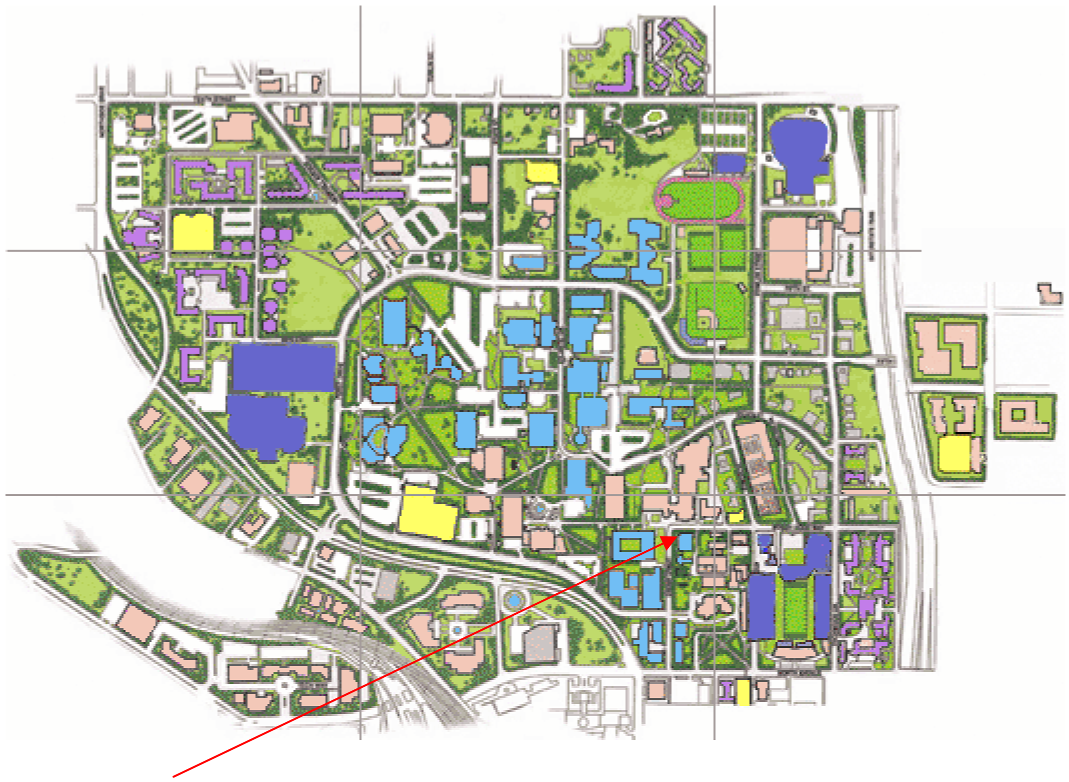
On April 20, 2004 LOGAN completed the installation of a 600kWe PC25C Combined Heat and Power (CHP) fuel cell installation in Fresno, CA. The system operating configurations allow for both grid parallel and grid independent energy service. The grid independent system is integrated with a Multi Unit Load Sharing (MULS) electronics package and static switch, which initial development was funded by ERDC CERL in 1999. This is the third fuel cell installation that uses the MULS System. The thermal recovery package installed in the project includes a 100-ton chiller that captures 210 degree F thermal energy supplied by the three fuel cells to support cooling loads on the first three floors of the host facility. The fuel cells also provide low-grade waste heat at 140 degrees F that furnishes thermal energy to 98 water source heat pumps located throughout the 12-story building during the winter months.

7.0 Host Facility Information

The Georgia Institute of Technology is one of the nation's top research universities, distinguished by its commitment to improving the human condition through advanced science and technology.

Georgia Tech's campus occupies 400 acres in the heart of Atlanta, where more than 16,000 undergraduate and graduate students receive a focused, technology-based education.

The Institute offers many nationally recognized, top-ranked programs. Undergraduate and graduate degrees are offered in the Colleges of Architecture, Engineering, Sciences, Computing, Management, and the Ivan Allen College of Liberal Arts. Georgia Tech consistently ranks among *U.S. News & World Report*'s top ten public universities in the United States. In a world that increasingly turns to technology for solutions, Georgia Tech is using innovative teaching and advanced research to define the technological university of the 21st century.



Fuel Cell Site Ga Tech campus map

Air Force Reserve Officer Training Corps (AFROTC) Detachment 165 headquarters, located at the tip of the red arrow on the campus map depicted above was the host site for the PEM demonstration project at GA Tech. The ROTC program provides professional military and academic training for students seeking a commission in the United States Air Force. Though academic classes are open to all students without obligation, the AFROTC program, for those pursuing a commission, includes two phases. The first two years constitute the General Military Course (GMC) and the last two years, the Professional Officer Course (POC). Additional information about the Detachment follows:

Established in 1946
Location: D. M. Smith Building, Bobby Dodd Way
Telephone: 404.894.4919
Fax: 404.894.1890
Website: www.afrotc.gatech.edu

8.0 Fuel Cell Installation

After reviewing several possible sites on the Georgia Institute of Technology campus, the headquarters building of ROTC Detachment 165, seen in Figure 1, was selected to host the installation because it met the Congressional requirement for placement on a DoD site. In December 2003, representatives of CERL, LOGAN and Georgia Tech held the project kick-off meeting. In January 2004, Plug Power shipped the unit, S/N 277, to GA Tech, where it remained in storage until the unit was placed on its pad in August 2004, as seen in Figure 2.

For eight months following the delivery of the unit LOGAN encountered significant resistance from GA Tech officials on the matter of liability insurance. The issue surfaced when the GA Tech facility's manager noted that LOGAN's liability insurance did not meet the university's minimum liability insurance requirements of $5,000,000. Thereafter LOGAN approached its insurance carrier to request an endorsement to satisfy the university's requirements. However the insurance carrier rejected the request. Three more months followed during which time LOGAN attempted to negotiate with GA Tech for a compromise, but that effort failed as well. In late June LOGAN approached its "project sponsor", GTRI for assistance. In early August, LOGAN and GTRI officials met to discuss an arrangement whereby GTRI would "lease" the equipment from LOGAN for the period of performance and carry the project under its insurance policy. The university facility manager accepted the solution, and once LOGAN and GTRI executed the documents in late September, the installation proceeded, but not as smoothly as anticipated. The original subcontractors hired to install the project were busy with other work, and could not support the project. With the onset of the holiday period, replacement crews were very difficult to find so it was not until early January that work commenced again.

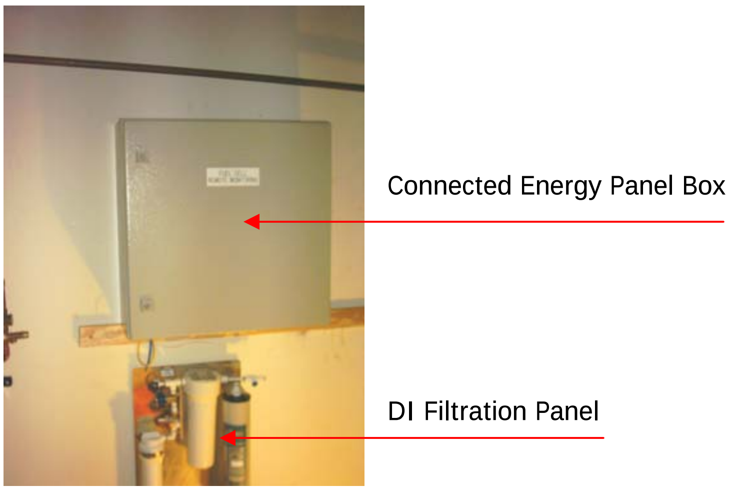
Figure 1, Fuel Cell Building

Figure 2, Fuel Cell Pad Site

Figure 1 pictures the front entrance of the GA Tech ROTC facility. Figure 2 is a photo of the unit on its pad. The gray boxes on the front of the unit contain the electric meter and emergency disconnect.

LOGAN satisfied the permitting requirements by marking buried utility wires and conduits, and submitting the data for a digging permit. GA Tech health and safety guidelines were maintained throughout the installation process. An air quality permit was not required at this site. The several tasks required to install the project took 154 man-hours to complete. With the connection of the Ethernet service occurring on February 28, 2005 the unit became fully operational.

Figure 3, A Deionized (DI) Water Panel, mounted on a wall of the building mechanical room provides filtered water to the fuel cell reservoir necessary for cell stack hydration. The Connected Energy Panel box that provides real-time web interface with the project is located directly above the DI panel.



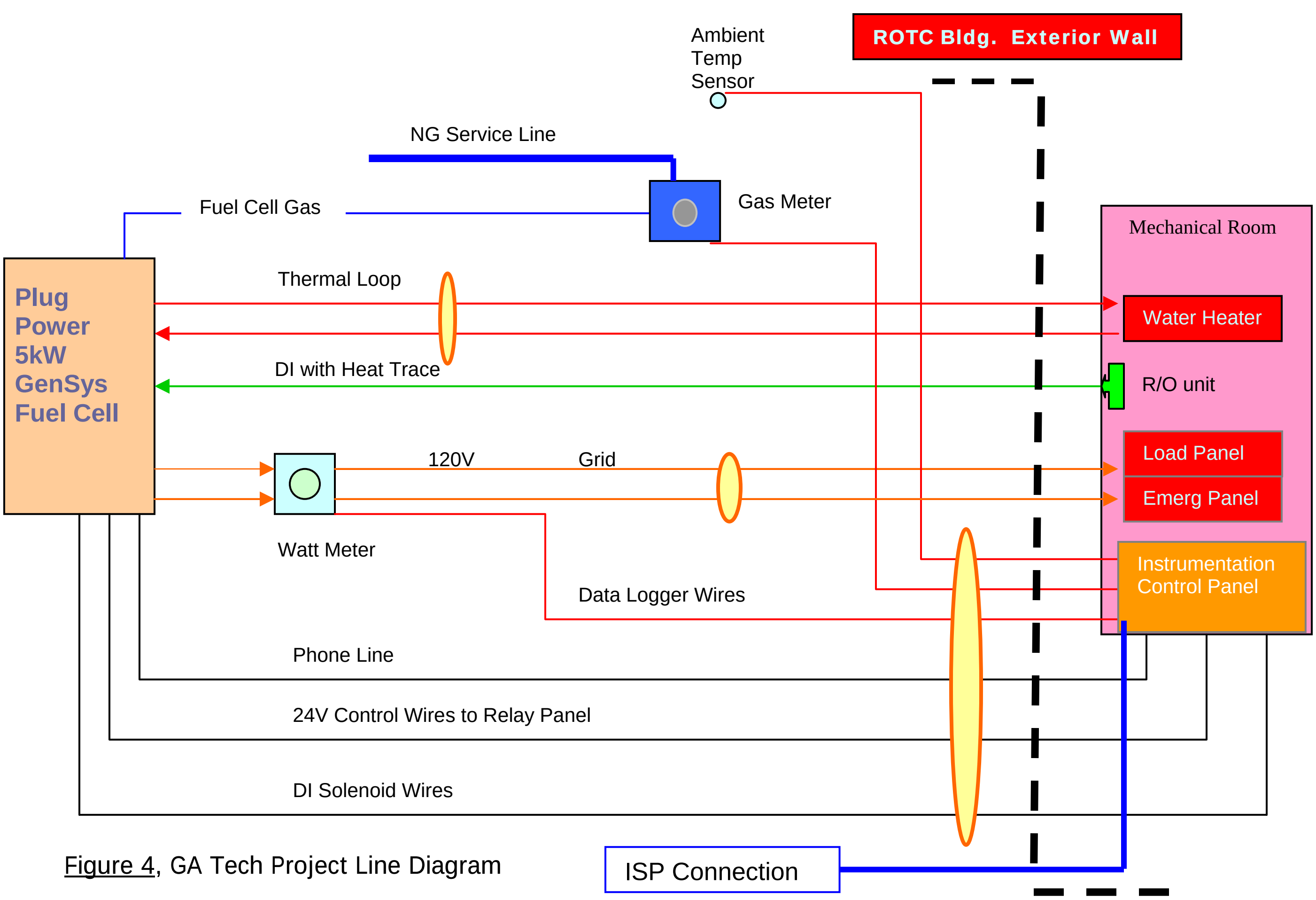


Figure 4, GA Tech Project Line Diagram

9.0 Electrical System

The GenSys5C MP5 inverter has a power output of 110/120 V_{ac} at 60 Hz, matching the connected loads within the large distribution panel seen at right in Figure 5. The installation includes both a grid parallel and a grid independent configuration as indicated in Figure 4 above. The fuel cell output connects to the larger panel in Figure 5 at a 50-amp circuit breaker, providing gird parallel energy service to the facility. The smaller circuit panel in the center of the photo was added to support designated “emergency circuits” in order to demonstrate the stand-by capabilities of the GenSys, should the grid fail during the demonstration period. The emergency panel has connected loads of approximately 35 amps that included UPS loads and other circuits that feed the Commander’s office.

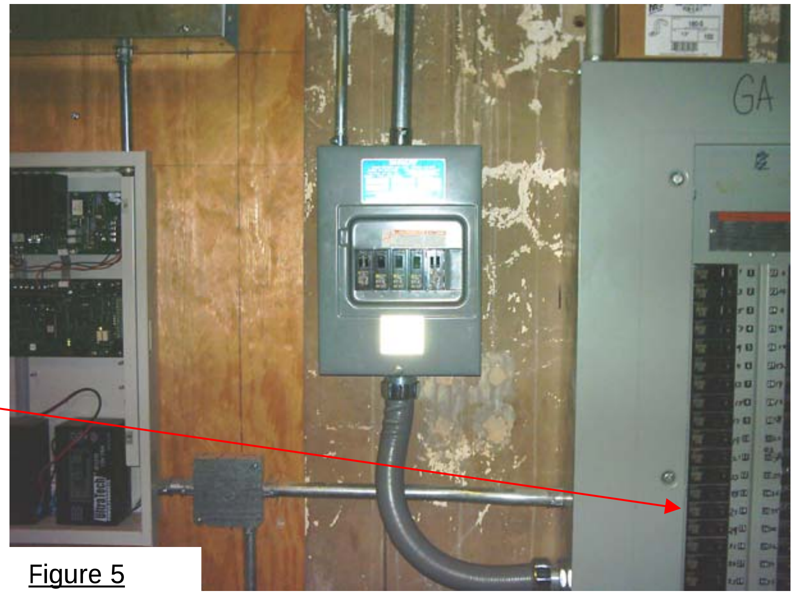


Figure 5

10.0 Thermal Recovery System

Fuel cell waste heat was plumbed to a Heliodyne heat exchanger in order to maintain the facility’s domestic hot water tank at 130 degrees F. Unfortunately, the tank supplied only two lavatories in the building with limited daytime use, so it did not achieve significant thermal utilization. See Figure 13 in appendix Section 2.

The Heliodyne is a “U” shaped coil-within-coil design that provides double wall protection between the heat source and the heat sink. It was designed primarily for the solar heating industry, but has proved to be very adaptable to the fuel cell industry as well. The Heliodyne, installed adjacent to the hot water heater in Figure 6 below, has its own pump that circulates the tank in a counter flow against incoming hot water provided by the fuel cell’s heat exchanger. The thermal recovery component of this demonstration provided an opportunity to evaluate the effectiveness of this heat transfer system, to refine installation methods and evaluate new materials. While the Heliodyne proved effective as a heat exchanger, the low heat recovery rates did not provide significant help to the project’s economics.

Figure 6, below, shows the method of providing fuel cell waste heat with the existing hot water tank. The “U” shaped coil is a Heliodyne Heat Exchanger that is mounted on the wall adjacent to the tank. The other major system components are indicated in the boxes below with arrows pointing to their locations.

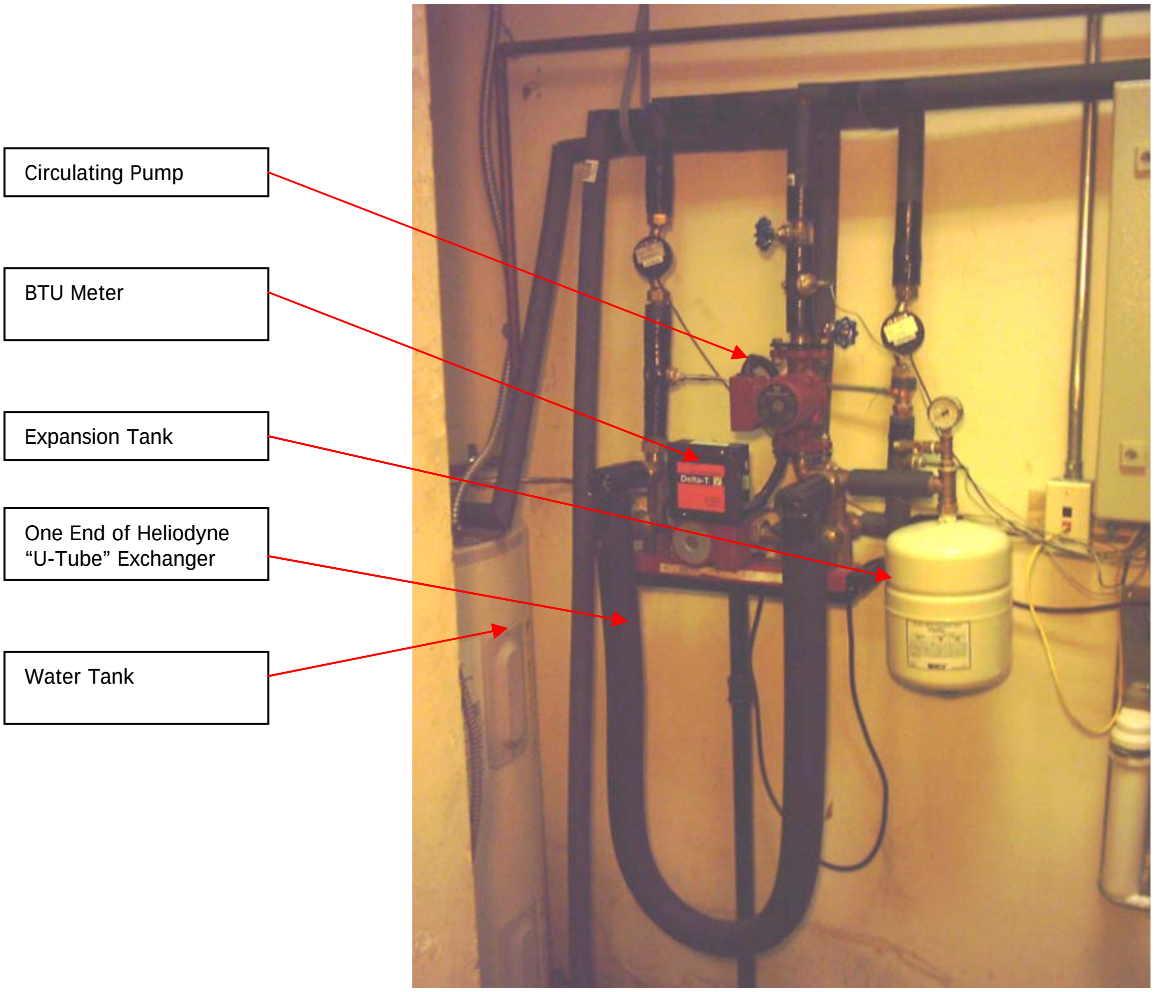


Figure 6

11.0 Data Acquisition System

Over the course of developing several sites in the CERL PEM Program, LOGAN often encounters great difficulty in acquiring a dedicated phone line for the fuel cell at every site. In the best case this has delayed starting the Demonstration Period by three weeks. Most sites have proven far more difficult. These experiences have taught LOGAN to be very explicit with the host POC at the kick-off meetings concerning the necessity for providing a dedicated phone line, since much of the success of the project is dependent upon reliable communications with the unit. With the recent introduction of improved controller software, LOGAN technicians can in some cases perform remote starts following incidental shutdowns, obviating the need for costly service calls to the site. The capability is routed through the fuel cell phone modem.

Based on its growing understanding and satisfaction with Ethernet supported remote monitoring, LOGAN decided once again to install a web-based, real time, data management and reporting system at the GA Tech ROTC site. To do this, LOGAN contracted with Connected Energy Corporation, CEC, to provide the required hardware and accompanying support services. The block diagram in Figure 7, below, describes the architecture of the CEC system operating at the site. The system provides a comprehensive data acquisition solution, and also incorporates remote control, alarming, remote notification, and reporting functions by means of a Virtual Private Network (VPN) that maintains connectivity between the fuel cell site and LOGAN's control center in Rochester, NY.

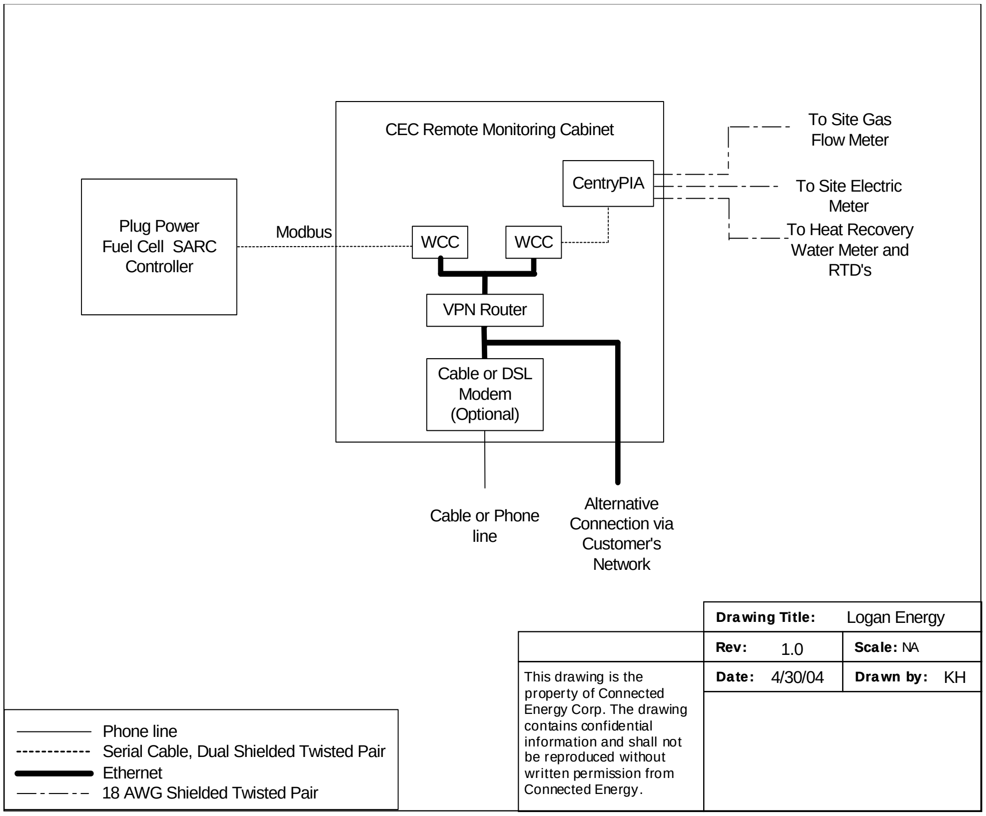


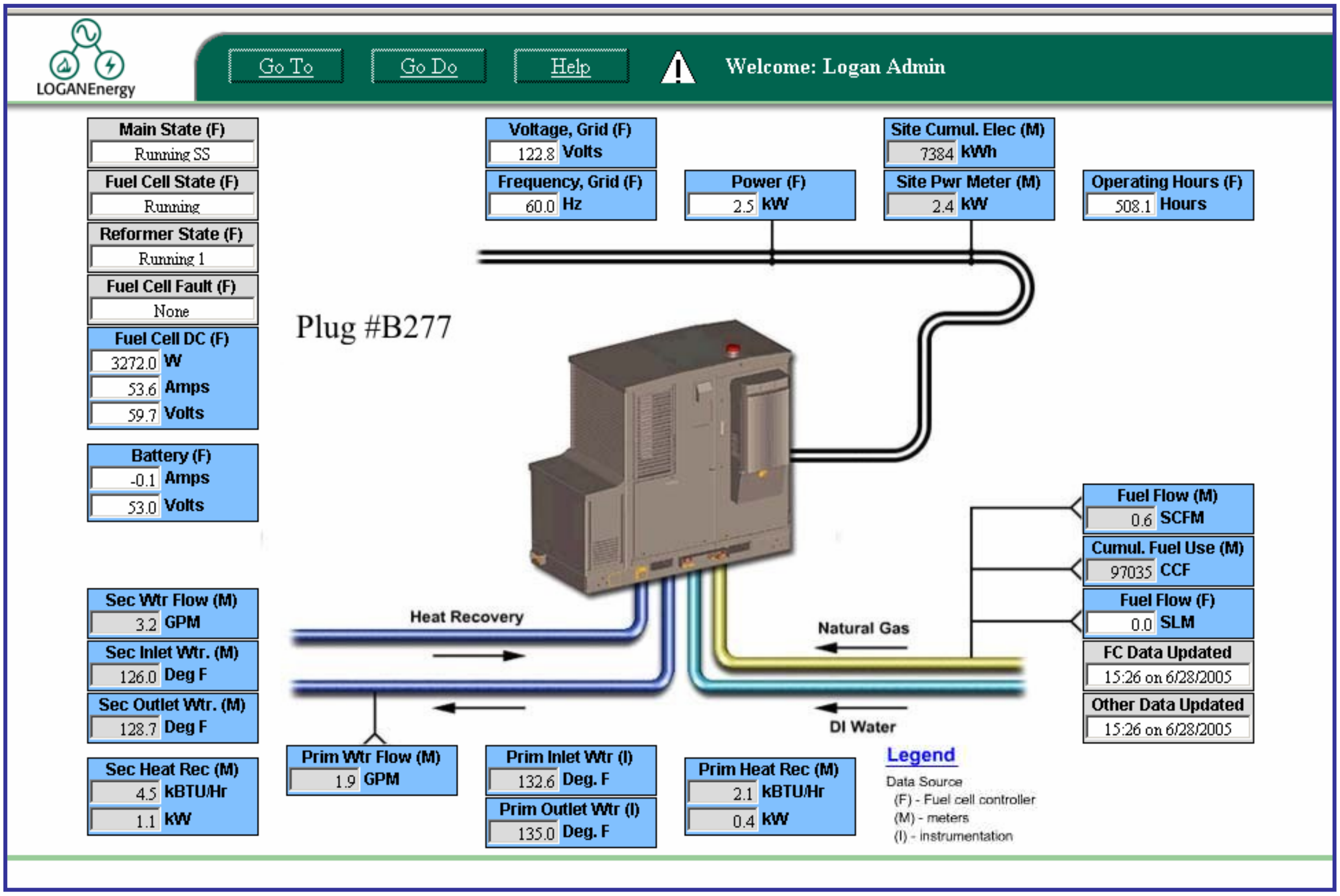
Figure 7, Connected Energy System Architecture

One important lesson that LOGAN has learned with this system is the critical role that individual sensors and electronic component parts play in supplying the data to the web interface. The CEC system requires very precise signals from the outputs of these devices. The gas meters, wattmeters, flow meters and thermal elements invariably require signal strength adjustment at the Remote Terminal Unit (RTU) terminals to insure that their discrete inputs are readable by the CEC system. Discovering the proper voltage range required for each signal loop is most often achieved by trial and error, requiring multiple site visits to establish a readable connection. In other instances LOGAN has discovered that flow metering devices and thermal couples often require high levels of maintenance and/or replacement to support continuous data collection. The learning curve has been rapid, however, and LOGAN is building a body of knowledge and expertise with this system that will yield improved results and better data as new sites are added to the WEB support system in the future. Figure 8 is an example of one of many data screens that are maintained by the CEC system and displayed on the web. Several sample charts are also attached to the Appendix that provides addition operating data analysis of the installation.

To view the operation of this unit online, go to:
https://www.enerview.com/EnerView/login.asp

Then login as: logan.user and enter the Password: guest. Select the box labeled GA Tech ROTC. Then you may navigate the site or other LOGAN sites using the tool bars or html keys.

Figure 8, Connected Energy Web Data Screen from 3:26 PM on 6/28/05 showing a number of performance data points for S/N B277.



12.0 Fuel Supply System

LOGAN connected the fuel cell gas inlet piping into the existing natural gas service line adjacent to the fuel cell pad and installed a flow meter to calculate fuel cell usage; pictured at right in Figure 9.   A regulator at the fuel cell gas inlet maintains the correct fuel cell operating pressure at 14 inches water column. While operating at a set point of 2.5kw the GenSys consumes approximately 3,300 BTUH achieving fuel efficiency of 26%.

Figure 9, Natural gas supply and fuel meter

13.0 Program Costs

Georgia Tech ROTC Headquarters

Project Utility Rates		**Utility**			
1) Water (per 1,000 gallons)	$1.69	City of Atlanta			
2) Utility (per KWH)	$0.0345	Georgia Power			
3) Natural Gas (per MCF)	$5.45	Georgia Gas Co.			
First Cost			**Estimated**	**Actual**	**Variance**
Plug Power 5 kW GenSys5C			$ 65,000.00	$ 65,000.00	$ -
Shipping			$ 1,800.00	$ 2,200.00	$ 400.00
Installation electrical			$ 1,250.00	$ 5,700.00	$ 4,450.00
Installation mechanical & thermal			$ 3,200.00	$ 6,225.00	$ 3,025.00
Watt Meter, Instrumentation, Web Package			$ 3,150.00	$ 2,145.00	$ (1,005.00)
Site Prep, labor materials			$ 925.00	$ 3,714.00	$ 2,789.00
Technical Supervision/Start-up			$ 8,500.00	$ 13,860.00	$ 5,360.00
Total			**$ 83,825.00**	**$ 98,844.00**	**$ 15,019.00**
Assume Five Year Simple Payback			$ 16,765.00	$ 19,768.80	$ 3,003.80
Forcast Operating Expenses	Volume	$/Hr	$/ Yr		
Natural Gas Mcf/ hr @ 2.5kW	0.0328	$ 0.18	$ 1,410.98		
Water Gallons per Year	14,016		$ 23.69		
Total Annual Operating Cost				$ 1,434.66	
Economic Summary					
Forcast Annual kWH		19710			
Annual Cost of Operating Power Plant		$ 0.073	kWH		
Thermal Recovery Credit		($0.007)	kWH		
Project Net Operating Cost		$ 0.066	kWH		
Displaced Utility cost		$ 0.035	kWH		
Energy Savings (Cost)		($0.031)	kWH		
Annual Energy Savings (Cost)		($614.85)			

Explanation of Calculations:

Actual First Cost Total is a *sum* of all the listed first cost components.
Assumed Five Year Simple Payback is the Estimated First Cost Total *divided by* 5 years.

Forecast Operating Expenses:

Natural gas usage in a fuel cell system set at 2.5 kW will consume 0.033 Thousand Cubic Feet (MCF) per hour. The cost per hour at $0.18 is 0.033 Mcf per hour *x* the cost of natural gas to the site, *$5.45* per MCF. The estimated annual cost of natural gas at 90% operational availability is the cost per hour *x* 8760 hours per year *x* 0.9 to equal $1,410.98.

Natural gas fuel cell systems set at 2.5 kW will consume 1.6 gallons of water per hour through the DI panel. The total volume of water consumed at 14,016 gallons per year is 1.6 gph *x* 8760 hours per year. The cost per year of $23.69 equals 14,016 gallons per year *x* cost of water to the site of *$1.69/1000gals*.

The Total Annual Operating Cost, $1,434.66 is the *sum of* the cost per year for the natural gas and the cost per year for the water consumption.

Economic Summary:

The Forecast Annual kWh at 19,710 kWh is the product of 2.5 kW set-point for the fuel cell system *x* 8760 hours per year *x* 0.9. The 0.9 is for 90% availability.
The Annual Cost of Operating the Power Plant at $0.073 per kWH is the Total Annual Operating Cost at $1,434.66 *divided by* the forecast annual kWh at 19,710 kWh.
The Estimated Annual Thermal Recovery Credit of -$0.007 equals 7800BTUH *divided by* 3414 BTU/kW. This is then *multiplied by* 0.9 *x* 0.1*x* the cost of electricity at *$0.0345* per kWh *x* (-1). As a credit to the cost summary, the BTUH value is expressed as a negative number.
The Project Net Operating Cost is the *sum* of the Annual Cost of Operating the Power Plant *plus* the Estimated Annual Thermal Recovery Credit.
The Displaced Utility Cost is the cost of electricity to Georgia Tech per kWh.

Energy Savings (cost) equals the Displaced Utility Cost *minus* the Project Net Operating Cost.

Annual Energy Savings (cost) equals the Energy Savings *x* the Forecast Annual kWh.

14.0 Milestones/Improvements

GenSys5C S/N 277 achieved 96% overall availability at GA Tech during this project. This is indicative of a positive trend in product improvements to the SU-1/GenSys 5C product platform since the inception of the CERL PEM Program in 2001.
The unit incorporated the MP-5 inverter designed by Plug Power to provide both grid parallel/grid synchronous and grid independent/load following capabilities. This capability is an important milestone in the development of the Gensys5 product and for the PEM Program itself, as it is a significant developmental step on the pathway to product commercialization. In this particular project, that capability allowed LOGAN to install an “emergency Load” panel at the ROTC building and transfer several circuits to that panel. These circuits included UPS loads in the both administrative offices and in the ROTC commander’s office. In the event of a utility failure (which did not occur during the project) these circuits would have remained energized by the fuel cell. The circuitry and functionality describing this can be seen in Figures 4 and 5 above.
S/N 277 also included the capability to recover waste heat through the addition of a Heliodyne heat exchanger attached to the domestic hot water loop for that purpose. Fuel cell heat is normally rejected through an air-cooled radiator on the unit, but the installation of this heat exchanger allowed LOGAN to supply fuel cell heat to satisfy the building’s hot water load. The system functioned adequately as demonstrated from the results of the thermal use recorded in Figure 11 in the Appendix section, averaging 1,500 Btuh during the project. However, LOGAN believes that heat recovery techniques need further refinement. One promising area includes future activities focused on integrating into fuel cell projects small commercial HVAC products that will significantly increase thermal recovery load factors. If successfully integrated into a fuel cell energy package, these products will add value to the fuel cell installation and reduce consumer energy costs for heating and cooling.

15.0 Decommissioning/Removal/Site Restoration

S/N 277 was decommissioned and removed from GA Tech during May 2006. The unit was cannibalized for good parts and then delivered to a local scrap yard.

Following the removal of the unit, LOGAN also removed the emergency electrical panel, deconstructed the thermal recovery system and reconnected the hot water tank to its original configuration.

At the completion of the site restoration LOGAN's work was inspected by the GA Tech facilities engineering department who indicated their satisfaction with the work.

16.0 Additional Research/Analysis

In order to provide remote monitoring and capture real time operating data, LOGAN installed a web based control interface with the unit as described in paragraph 11 above. This system allowed LOGAN to store and retrieve operating and performance data over the life of the project. One of the fuel cell operating screens used to capture this information can be viewed in Figure 8 above. Some of this data is reproduced in Figures 10 – 13 in Appendix Section 1. The data charts provide interval performance for thermal recovery, electric power generation and system efficiency. The data indicates that S/N 277 operated well within the manufacturer's performance specifications and at 96% availability achieved significantly greater operational reliability than required by CERL's performance specifications.

In addition to the above, LOGAN also performed a series of harmonics tests on the unit under normal operations using an Amprobe HarmonaLink 2 testing device; the results of this testing are presented in Appendix Section 2 below. The data describes four test conditions; a. stand alone grid voltage and harmonics, b. the inverter voltage and current harmonics in a grid connected configuration at 5W.

The IEEE Standard, 519-1992, that governs the performance of the Plug Power states that

1. Total Voltage Harmonic Distortion at rated inverter output is limited to 5% of fundamental frequency voltage, and
2. Individual Frequency Harmonics Distortion is limited to 3% of fundamental frequency voltage.

Referring to the Charts in Appendix 2, the test results indicate that at the time the measurements were taken, no individual Frequency Harmonic exceeded the IEEE standard of 3%, and that total Voltage Harmonic Distortion at 2.3% was well below the upper IEEE limit of 5%.

17.0 Conclusions/Summary

This project had its share of difficulties getting started that were new to LOGAN and to CERL PEM projects. They all related to providing services to a major university and gaining experience in dealing with a new set of regulations governing the delivery of university service. The insurance requirements imposed by the university board were significantly greater than LOGAN could provide for a demonstration project and at first seemed to doom the project. However with the assistance of the GA Tech Research Institute (GTRI), LOGAN entered into a temporary agreement whereby the fuel cell was placed into a technology lease with GTRI who was then able to bring the project directly under their auspices, thereby satisfying the insurance requirements through their liability policy.

LOGAN encountered a similar difficulty when hiring subcontractors to perform the fuel cell installation tasks. Once again the imposition of severe liability insurance requirements caused the rejection of smaller electrical and mechanical firms in favor of larger ones whose interest in the relatively small project was reflected in their very significant pricing to do the work. Consequently the project ran over budget by $15,000.

Notwithstanding these obstacles, the GA Tech project proved successful because of support from the stakeholders who worked cooperatively to solve the major issues. As a result the test period concluded with a total 8,450 fuel cell load hours, and achieved overall availability of 96%.

In summary, the lesson learned at this site will have positive implications for future PEM operations and customer services. As these experiences are transferred to future installations they will directly benefit the community of CERL projects and equally enhance the reliability of future Plug Power products. Finally, this project elevated the awareness of fuel cell technology for students at GA Tech, for researchers at GTRI and for the growing fuel cell community in Georgia.

Appendix

1) Monthly Performance Data

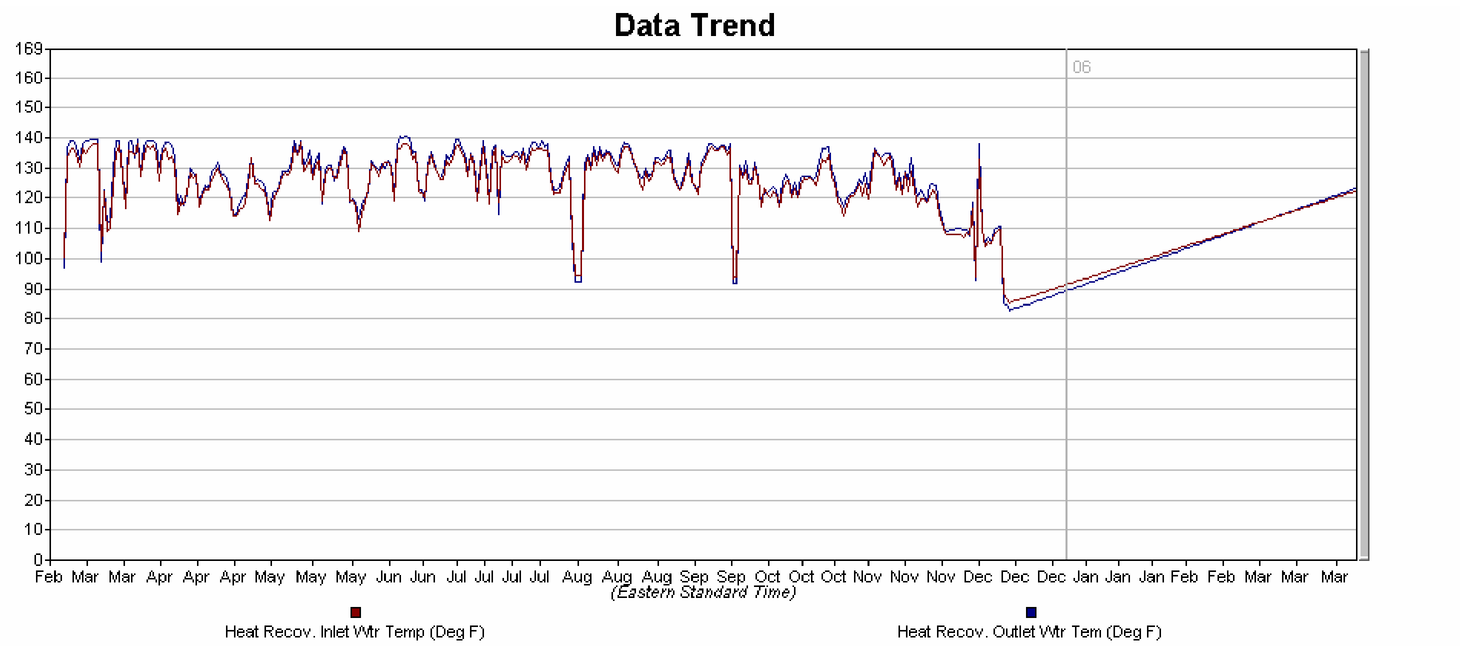


Figure 10, Heat Recovery Temperature Delta from Febuary 2005 through March 2006

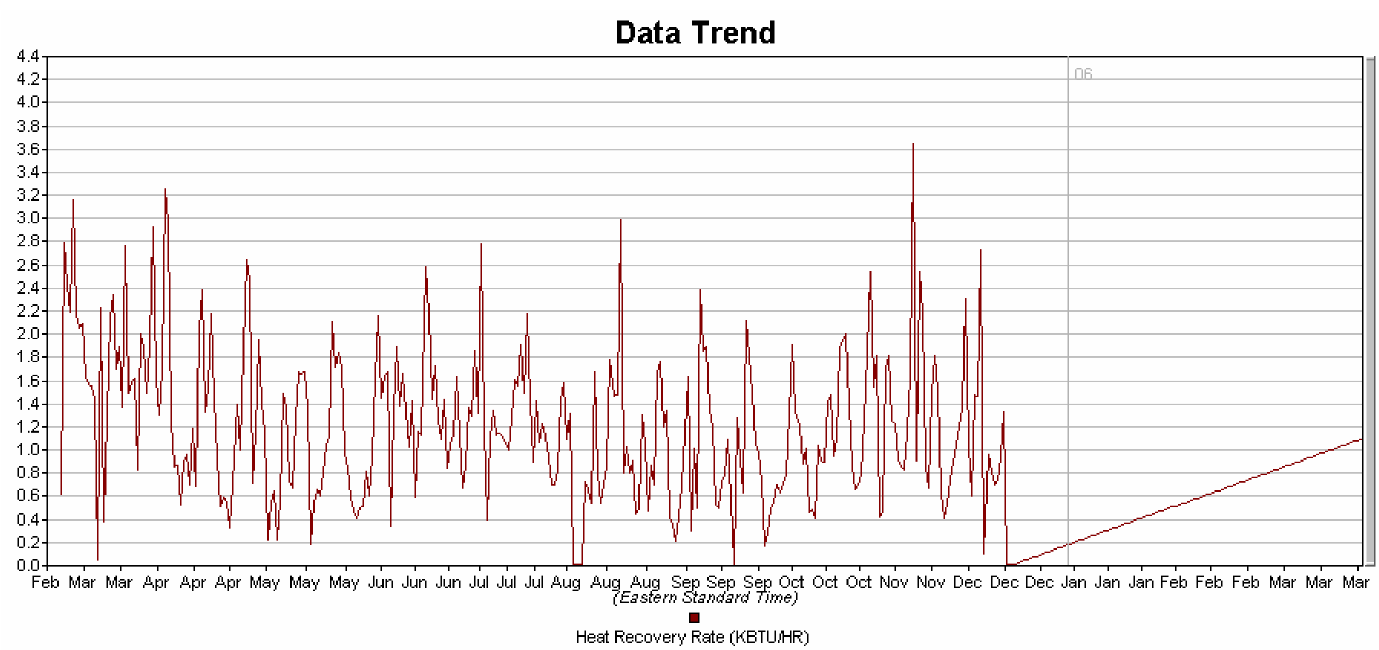


Figure 11, Heat Recovery Rate in KBTU/hr. from Febuary 2005 through March 2006

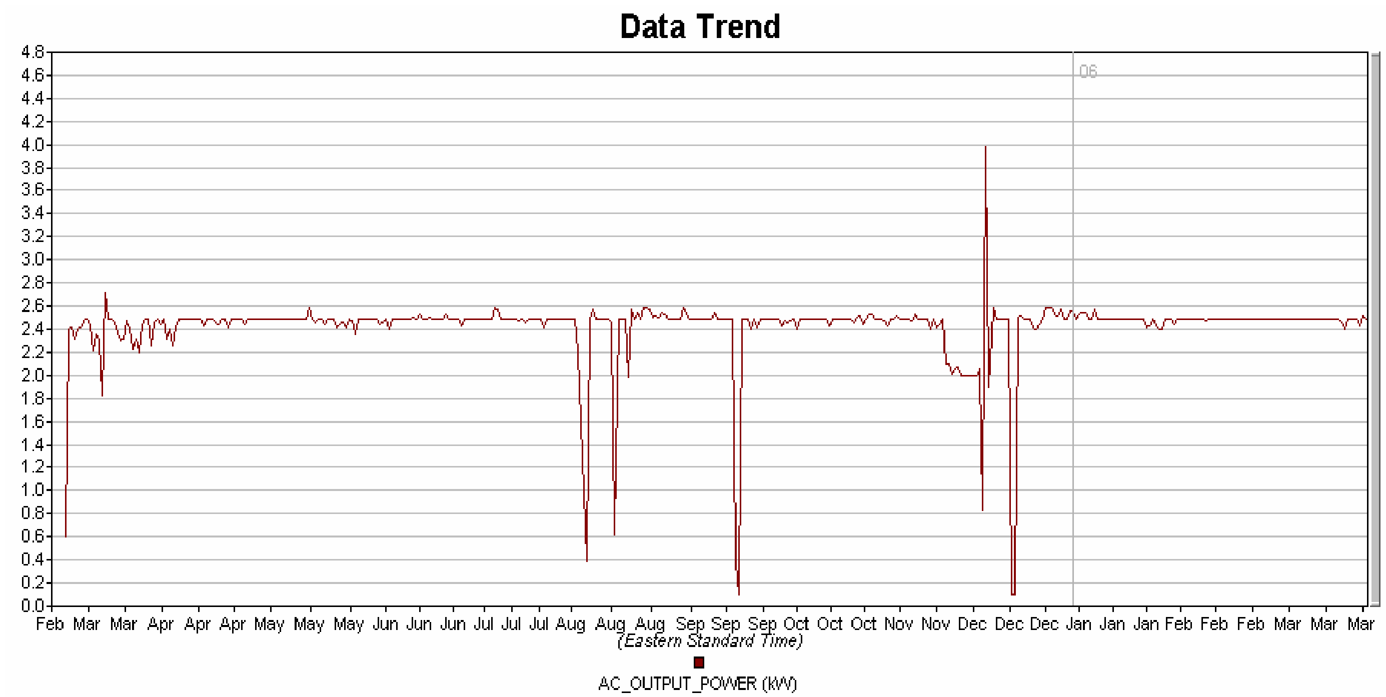


Figure 12, AC Output Power in kW from Febuary 2005 through March 2006

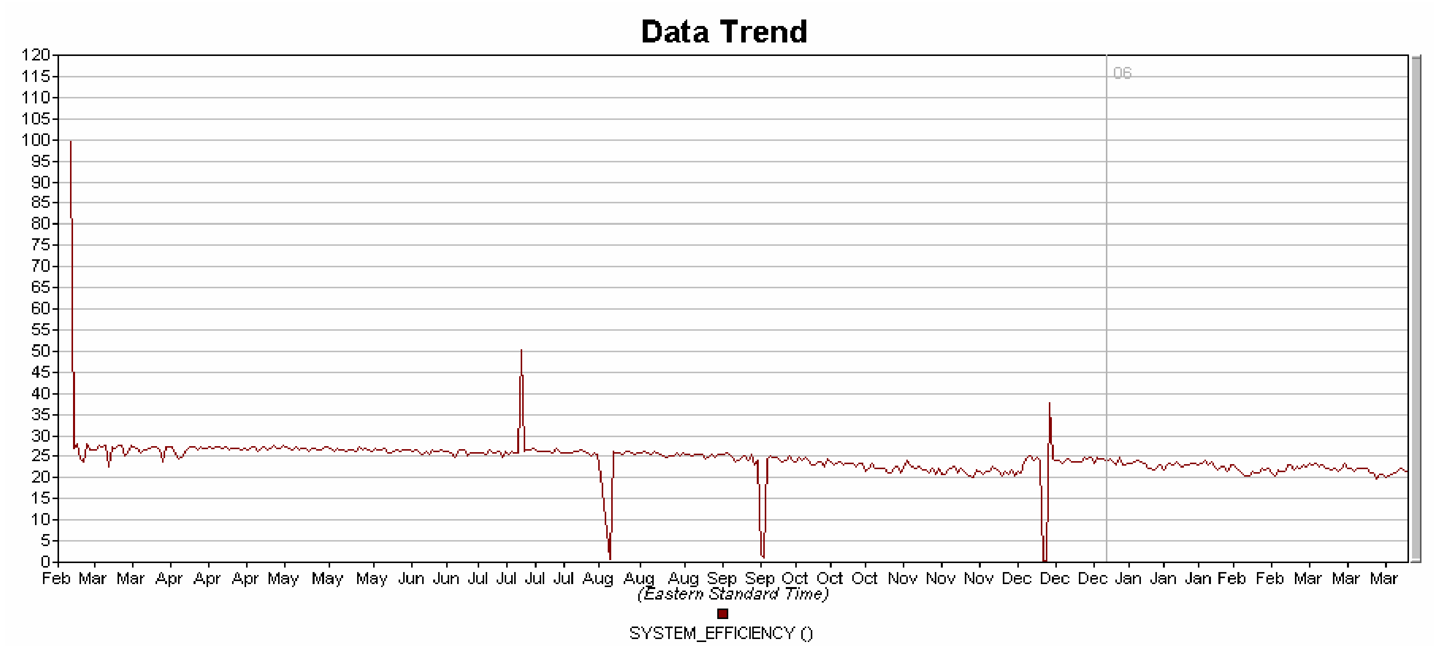
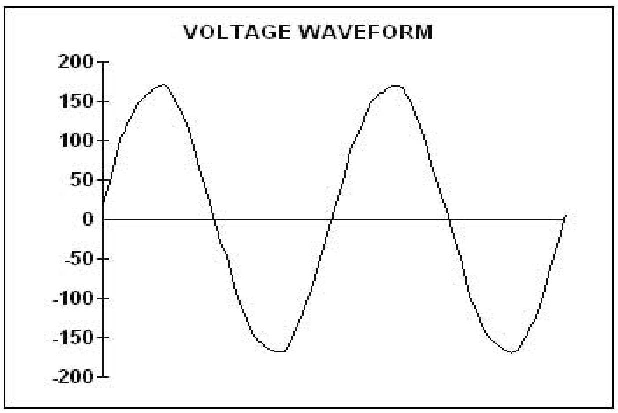


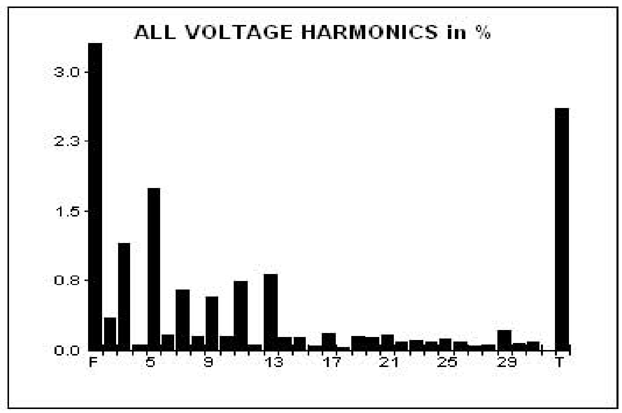
Figure 13, Overall System Efficiency (%) from February 2005 through March 2006

2) Fuel Cell Harmonics Testing

5 kW Voltage Harmonics

Amprobe HarmonaLink II VOLTAGE Waveform Analysis





VOLTAGE ODD HARMONICS

H	%	RMS	Angle
1	100.0	119.67	+0
3	1.2	1.38	+121
5	1.7	2.08	-109
7	0.7	0.78	+163
9	0.6	0.69	-99
11	0.7	0.89	+132
13	0.8	0.97	+139
15	0.1	0.15	+35
17	0.2	0.22	-68
19	0.1	0.17	-25
21	0.2	0.20	-149
23	0.1	0.13	-59
25	0.1	0.14	+117
27	0	0	
29	0.2	0.24	-20
31	0	0	
Tripln	1.3	1.58	
Odd	2.5	3.04	
THD	2.6	3.10	

VOLTAGE EVEN HARMONICS

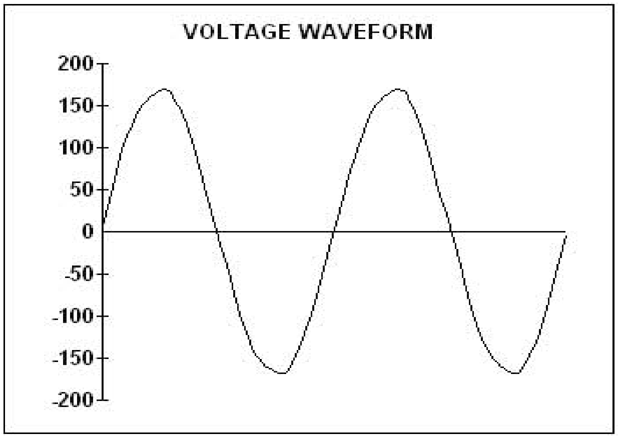
H	%	RMS	Angle
2	0.3	0.41	-178
4	0	0	
6	0.2	0.20	-132
8	0.1	0.17	-130
10	0.2	0.18	-134
12	0	0	
14	0.1	0.15	-162
16	0	0	
18	0	0	
20	0.1	0.16	-157
22	0	0	
24	0	0	
26	0	0	
28	0	0	
30	0	0	
Even	0.5	0.61	

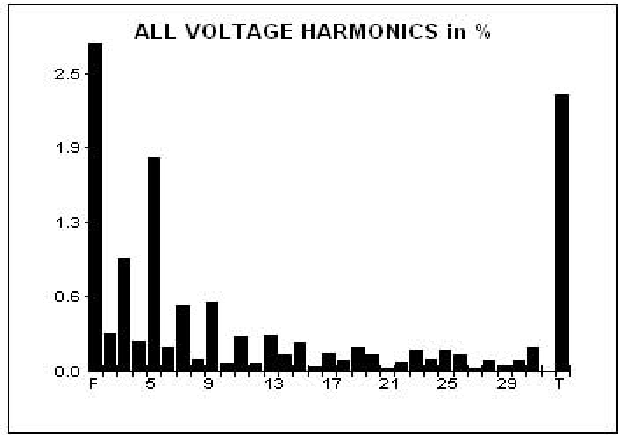
VOLTAGE TOTALS

Total	119.71 rms
Peak	170.43
Average	107.38
DC Comp	0.62
Crest Factor	1.42
Form Factor	1.11
Fund Freq	60.02 Hz
Fundamental	119.67 rms
Harmonics	3.10 rms
THD Percent	2.6%
K Fctr	1.04

Grid only Voltage Harmonics

Amprobe HarmonaLink II VOLTAGE Waveform Analysis





VOLTAGE ODD HARMONICS

H	%	RMS	Angle
1	100.0	119.42	+0
3	0.9	1.12	+110
5	1.8	2.13	-123
7	0.5	0.65	+152
9	0.6	0.69	-110
11	0.3	0.34	+112
13	0.3	0.35	+131
15	0.2	0.28	-28
17	0.1	0.17	-119
19	0.2	0.24	-166
21	0	0	
23	0.2	0.21	-142
25	0.2	0.20	-16
27	0	0	
29	0	0	
31	0.2	0.24	+62
TripIn	1.2	1.38	
Odd	2.3	2.69	
THD	2.3	2.77	

VOLTAGE EVEN HARMONICS

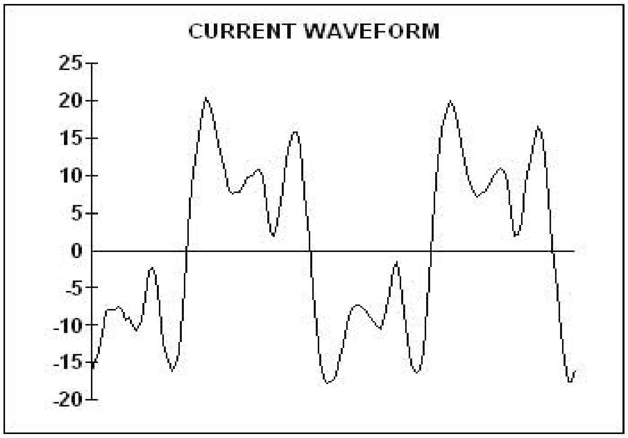
H	%	RMS	Angle
2	0.3	0.37	+162
4	0.2	0.29	-147
6	0.2	0.23	+173
8	0	0	
10	0	0	
12	0	0	
14	0.1	0.16	-130
16	0	0	
18	0	0	
20	0.1	0.17	-129
22	0	0	
24	0.1	0.12	-74
26	0.1	0.17	-121
28	0	0	
30	0	0	
Even	0.6	0.66	

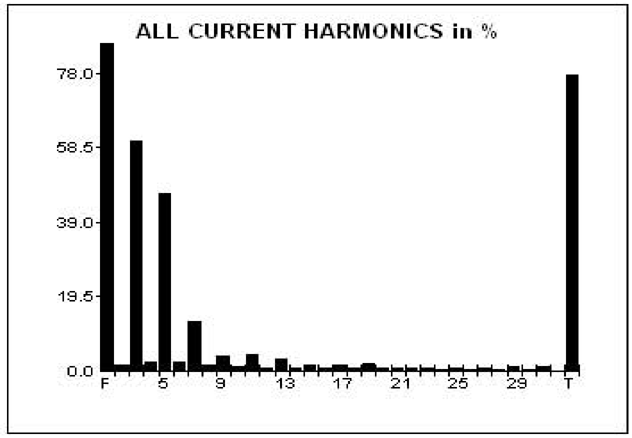
VOLTAGE TOTALS

Total	119.45 rms
Peak	169.04
Average	107.07
DC Comp	0.58
Crest Factor	1.42
Form Factor	1.12
Fund Freq	60.02 Hz
Fundamental	119.42 rms
Harmonics	2.77 rms
THD Percent	2.3%
K Fctr	1.03

5 kW Current Harmonics

Amprobe HarmonaLink II CURRENT Waveform Analysis





CURRENT ODD HARMONICS

H	%	RMS	Angle
1	100.0	9.03	+0
3	60.2	5.44	+55
5	46.3	4.18	+124
7	12.9	1.17	-80
9	3.9	0.36	+109
11	4.3	0.39	-25
13	3.0	0.27	+164
15	1.6	0.14	-93
17	1.2	0.11	-90
19	1.7	0.16	+138
21	0.7	0.06	+74
23	0.6	0.06	+62
25	0.5	0.05	-51
27	0.5	0.05	+145
29	1.0	0.09	-34
31	1.2	0.11	-6
TripIn	60.4	5.45	
Odd	77.4	6.99	
THD	77.5	7.00	

CURRENT EVEN HARMONICS

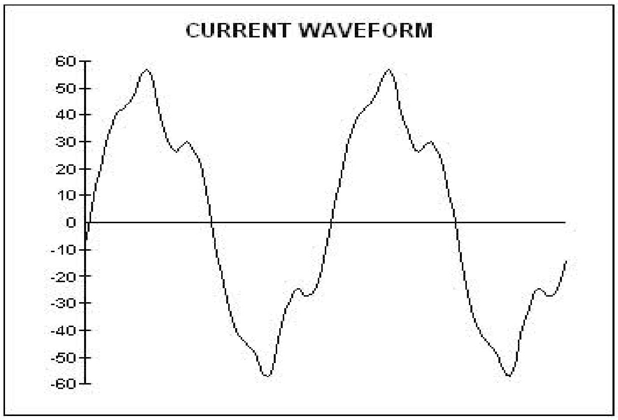
H	%	RMS	Angle
2	1.6	0.14	-126
4	2.3	0.21	-72
6	2.2	0.20	-83
8	1.2	0.11	-109
10	1.1	0.10	-57
12	0.5	0.04	-100
14	0.8	0.07	-58
16	0.7	0.07	+39
18	0.5	0.05	+159
20	0.5	0.05	+131
22	0.4	0.04	+97
24	0.2	0.02	+18
26	0.3	0.03	-180
28	0.3	0.03	-19
30	0.2	0.01	-58
Even	4.2	0.38	

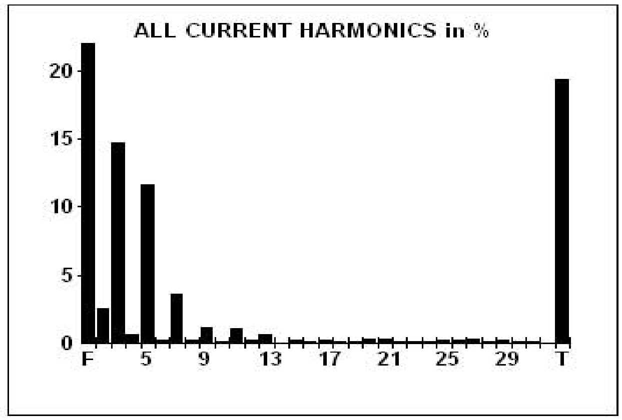
CURRENT TOTALS

Total	11.43 rms
Peak	19.82
Average	10.36
DC Comp	0.16
Crest Factor	1.73
Form Factor	1.10
Fund Freq	59.94 Hz
Fundamental	9.03 rms
Harmonics	7.00 rms
THD Percent	77.5%
K Fctr	7.23

Grid only Current Harmonics

Amprobe HarmonaLink II CURRENT Waveform Analysis





CURRENT ODD HARMONICS

H	%	RMS	Angle
1	100.0	35.21	+0
3	14.7	5.18	-86
5	11.6	4.07	-24
7	3.6	1.27	+139
9	1.1	0.39	-20
11	1.1	0.38	-170
13	0.6	0.23	-35
15	0.2	0.07	+89
17	0.2	0.07	+177
19	0	0	
21	0.3	0.12	+176
23	0	0	
25	0.2	0.07	+138
27	0.3	0.09	-56
29	0.2	0.07	+94
31	0	0	
TripIn	14.8	5.20	
Odd	19.1	6.74	
THD	19.3	6.80	

CURRENT EVEN HARMONICS

H	%	RMS	Angle
2	2.5	0.88	+132
4	0.6	0.21	+48
6	0.2	0.09	+150
8	0.2	0.05	+170
10	0.1	0.05	+149
12	0.2	0.07	-148
14	0	0	
16	0.1	0.05	-13
18	0.1	0.04	-98
20	0.3	0.10	-151
22	0	0	
24	0	0	
26	0.2	0.07	-27
28	0	0	
30	0.1	0.05	-118
Even	2.6	0.93	

CURRENT TOTALS

Total	35.86 rms
Peak	57.18
Average	32.75
DC Comp	0.57
Crest Factor	1.59
Form Factor	1.09
Fund Freq	60.04 Hz
Fundamental	35.21 rms
Harmonics	6.80 rms
THD Percent	19.3%
K Fctr	1.60

Georgia Tech ROTC Headquarters Atlanta, Georgia

	Mar-05	Apr-05	May-05	Jun-05	Jul-05	Aug-05	Sep-05	Oct-05	Nov-05	Dec-05	Jan-06	Feb-06	Mar-06
Run Time (Hours)	684	684	744	711	744	616	681	744	716	691	744	672	744
Time in Period (Hours)	696	720	744	720	744	744	720	744	720	744	744	672	744
Availability (%)	98%	95%	100%	99%	100%	83%	95%	100%	99%	93%	100%	100%	100%
Energy Produced (kWe-hrs AC)	1645.0	1686.0	1863.0	1835.3	1850.0	1850.0	1701.0	1852.0	1705.0	1720.0	1863.0	1682.8	1847.0
Output Setting (kW)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Average Output (kW)	2.40	2.46	2.50	2.58	2.49	2.52	2.50	2.49	2.38	2.49	2.50	2.50	2.48
Capacity Factor (%)	47.27%	46.83%	50.08%	50.98%	49.73%	41.67%	47.25%	49.78%	47.36%	46.24%	50.08%	50.08%	49.65%
Fuel Usage, LHV (kWe-hrs AC)	6207.0	6284.0	7764	7115	7172	6079	6999	8047	7940	7397	8072	7739	8542
Fuel Usage, LHV (BTUs)	2.12E+07	2.14E+07	2.65E+07	2.43E+07	2.45E+07	2.07E+07	2.39E+07	2.75E+07	2.71E+07	2.52E+07	2.75E+07	2.64E+07	2.91E+07
Fuel Usage (SCF)	20937	21197	26189	24000	24192	20505	23608	27143	26782	24951	27228	26104	28813
Electrical Efficiency (%)	26.52%	26.85%	24.01%	25.81%	25.81%	25.51%	24.32%	23.03%	21.49%	23.27%	23.09%	21.76%	21.64%
Thermal Heat Recovery (BTUs)	1278680	966280	788520	960230	994820	747500	686100	709300	828800	389600	0	0	0
Heat Recovery Rate (BTUs/hour)	1869.415	1412.69	1059.84	1350.53	1337.12	1213.47	1007.49	953.36	1157.54	563.82	0	0	0
Thermal Efficiency (%)	6.04%	4.51%	2.98%	3.96%	4.07%	3.60%	2.87%	2.58%	3.06%	1.54%	0.00%	0.00%	0.00%
Overall Efficiency (%)	32.56%	31.35%	26.99%	29.77%	29.88%	29.12%	27.19%	25.61%	24.55%	24.81%	23.09%	21.64%	21.64%
Number of Scheduled Outages	0	0	0	0	0	0	0	0	1	0	0	0	0
Scheduled Outage Hours	0	0	0	0	0	0	0	0	4	0	0	0	0
Number of Unscheduled 0Outages	1	1	0	1	0	1	1	0	0	2	0	0	0
Unscheduled Outage Hours	12	36	0	9	0	128	39	0	0	53	0	0	0

2) Daily Work Logs

LOGANEnergy Field Technicians

January ’04 – December ’05

Additional work logs are being located.

LOGANEnergy Corp.					
Monthly Site Report					
Period	January-04				
Site	GA TECH				
Engineer	**Date**	**PP S/N**	**Activity**	**Mileage**	**Hours**
Harvell	1/28/2004	277		275	2.5
			Visited site for first time. Met the Colonel and my electrician on site.		

LOGANEnergy Corp.					
Monthly Site Report					
Period	February-04				
Site	GA TECH				
Engineer	**Date**	**PP S/N**	**Activity**	**Mileage**	**Hours**
Harvell	2/2/2004	277			3
			Phone calls and Preparation.		
Harvell	2/3/2004	277			6
			More preparation for meeting tomorrow. Drove to Atlanta.		
Harvell	2/4/2004	277		275	3
			Met with David Chandler, the fire chief, 2 men from utilities, and 2 men from Zone 4 Buildings to go over the project again and satisfy concerns. We will begin getting utilities to mark underground lines and David will consult architects about going through the window. It's going to be a tough project.		

LOGANEnergy Corp.					
Monthly Site Report					
Period	March-04				
Site	GA TECH				
Engineer	**Date**	**PP S/N**	**Activity**	**Mileage**	**Hours**
Harvell	3/11/2004	277		171	5
			Went to site to mark the ground where we want utilities located. Contacted David Chandler to get GT to locate their lines and Utilities Protection Services to locate the rest.		
Harvell	3/22/2004	277		256	8

			Went to site to draw where the utilities are located. In the process, I was "run off" because I didn't have a parking sticker. Went to get a sticker and the nearest place to park was on the other side of Interstate 75. David Chandler is helping me get a contractors parking permit, but it's going to cost us $50 per month.		

LOGANEnergy Corp.					
Monthly Site Report					
Period	May-04				
Site	GA TECH				
Engineer	**Date**	**PP S/N**	**Activity**	**Mileage**	**Hours**
Harvell	5/3/2004	277			9
			Drove to Atlanta and installed fuel cell pad.		
Worley	5/3/2004	277		160	8
			Installation Work: Went to Home Depot and purchased material to build pad. Returned home to complete prework on pad (measure, cut, and drill lumber). Drove to GA Tech to meet Mike Harvell and assemble pad.		
Harvell	5/4/2004	277		345	3
			Drove to Augusta.		
Worley	5/20/2004	277			
			Stopped by to measure parking area, street, and fuel cell site. Determined exact distance that fuel cell will have to be moved with the crane.		

LOGANEnergy Corp.					
Monthly Site Report					
Period	August-04				
Site	GA TECH				
Engineer	**Date**	**PP S/N**	**Activity**	**Mileage**	**Hours**
Worley	8/27/2004	277			
			GA Tech, #277, was sitting on the pad with stack installed by 9:30am.		
Worley	8/27/2004	277		80	4
			Travel to site and set fuel cell on pad. Installed stack. Drove Home		

LOGANEnergy Corp.					
Monthly Site Report					
Period	January-05				
Site	GA TECH				
Engineer	**Date**	**PP S/N**	**Activity**	**Mileage**	**Hours**
Worley	1/7/2005	277			2

			Friday - Met with David Chandler, Mark Hopkins, and Todd Bermann (GA Tech facilities). Discussed site access and conduit/mechanical piping		
Worley	1/10/2005	277		600	38
			Monday - Met with Gene's Plumbing and Shifflett Electric to discuss installation work. Contractors will submit bids at a later date. Stopped by Home Depot to pick up materials for the electric meter/disconnect.		
			Tuesday - Went to Lowe's to purchase copper fittings and valves for the Heliodyne. Spent the remainder of the day preparing equipment for installation. Worked on Heliodyne - sweated new piping in order to prep unit for GA Tech installation. Removed excess copper tubing and fittings from McPherson. Made bracket to install unit on wall. Completed flow calculations to determine system requirements at GA Tech. The current pumps are acceptable if we use 3/4" PEX tubing. Mounted disconnect, receptacle, and meter base on end bracket. Wired up bracket so that it is ready to install.		
			Wednesday -Stopped by Home Depot to pick up wall/concrete anchors for equipment. Went back down to Atlanta to install components including Heliodyne, Connected Energy box, and end bracket assembly.		
			Thursday - Ordered replacement seals for the Heliodyne. I also ordered 3/4"x1/4" hex bushings for RTD installation. Contacted Glen Hickman at GTRI to check on status of phone/internet service. I provided Glen a digital photograph showing desired jack locations. Received a quote from Gene's Plumbing.		
			Friday - Went back to Tech to meet with another plumber and electrician. More quotes to follow.		
Worley	1/21/2005	277		34	6
			Monday - Received electrical quote from Mickey Stell of Brooks, Berry, and Haynie. The quote was still high. Asked Mickey to re-quote on a cost plus (20%) basis.		
			Tuesday - Met with Gerald Maithis of Industrial Electrical Contractors in Dalton, GA. Took him a set of drawings fro the GA Tech job. Estimates that the Jon will be somewhere in the $1800 range for electrical work. Providing that we run the underground conduit.		
			Friday - Contacted additional plumbers to get quotes on CHP piping. Called the GA one call number to get utility locates near the site. The request requires 72 hours to process. Confirmation # 01215017053.		
Worley	1/28/2005	277		750	50

			Monday - Met with "John the Plumber" from Cartersville. Received quote the same day. Scheduled to begin work on Tuesday. Took measurements on window so that I could cut a piece of plywood to cover the opening that the pipes will pass through.		
			Tuesday - Plumbers arrived on site approximately 2 hours late. Plumbers begin work. Had to leave site in order to pick up material. It took several hours to tunnel under the first sidewalk. Used a jackhammer to break up second sidewalk at section of pavers. Ran all underground PEX and PVC conduit.		
			Wednesday - Plumbers again late to arrive. Started work on interior piping and tied in gas line. We were unable to finish up inside since the ROTC unit insisted on locking everything up at 6:00pm.		
			Thursday - Plumbers late again. Finished up running PEX inside the building at around 5:00pm. I sent them home around 6:00pm. They did not finish up the final connections to the Heliodyne or hot water heater. The PEX also needs to be connected to the underground run outside the window.		
			Friday - I went back to Tech to inspect the work done by the plumbers. I had to rework the gas line, as they did not run it square and plumb. I found several loose fittings when I was reworking the piping. Once complete, I painted the gas line so that it looks nice.		

LOGANEnergy Corp.					
Monthly Site Report					
Period	February-05				
Site	GA TECH				
Engineer	**Date**	**PP S/N**	**Activity**	**Mileage**	**Hours**
Worley	2/4/2005	277		300	26
			Monday - Took my air compressor down to GA Tech to pressure test the PEX tubing. I plugged the ends of the tubing and pressurized the lines with air to 50 PSI. Then I shut the valve and let the system stand. After approximately 3 hours there was no measurable drop in pressure.		
			Tuesday - Wrote letter-outlining adjustments to bill submitted by plumbing contractors. Outlined work not complete and material supplied by Logan Energy.		
			Wednesday - Met with Gerald Maithis from IEC to go over electrical installation at GA Tech. Ordered 60amp single pole breaker for ITE panel in basement.		

			Friday - Electricians on site to run conduit and wire for fuel cell and communications. Work complete around 6:00 pm. Contacted GA Tech utilities to get an "as built" wiring diagram for the ROTC offices. Identified two lighting circuits to be placed in the critical load panel. Had the electricians run additional wires from the Critical Load Panel to the Main Panel to facilitate the addition of more critical load circuits later.		
Worley	2/9/2005	277		450	24
			Monday - spent part of the day cleaning up the piping where it exits the ground floor window. I had to install new brackets to hold the plywood in place over the window. The previous brackets were not substantial enough to keep the board tightly in place. I also began charging the batteries individually. I have a 12v charger that puts them through a deep charge cycle. It took it about 4 hours to recover the first battery.		
			Tuesday - continued charging batteries. Filled the stack with therminol. I also mounted phone/data jack near the Connected Energy box.		
			Wednesday - Ran the CAT5 and phone wiring from the Connected Energy box to the phone room. I labeled the wires and left them so that the IT technicians could terminate. This eliminated the need for an outside contractor to install the wiring. I also filled the CHP loop and noticed that the flowmeter was leaking internally. I drained the system and swapped the flowmeter with the on I had planned to use for the secondary CHP loop. On the second attempt at filling the system, everything went OK and no leaks were found. I pressurized the system to 15 psi and left it there.		
Worley	2/18/2005	277			32
			Monday - Connected water to the DI panel and wired up flowmeter in primary CHP loop. Soldered appropriate resistor across pulse wires. Finished up insulating the PEX tubing at the Heliodyne.		
			Tuesday - Began wiring up pulse wires at the terminal strips mounted inside the fuel cell. Powered up the SARC and updated the software and battery charging set points. I then let the system GRID CHARGE. I had to leave at lunchtime to get back in time to meet FEDEX for scheduled freight pick-up.		

			Wednesday - changed the wiring in the CAT5 jack to from the 568A standard to the 568B standard. I also turned on the natural gas supply and leak checked the gas line. It was difficult to set the gas pressure and I suspect that there may be a problem with the regulator salvaged from Robins AFB. The gas pressure is acceptable, but it varies a lot.		
			Thursday - Finished wiring the pulse wires into the terminal strips. Installed filters in the DI panel and set the 6:1 ratio across the RO filter. Then I turned on SOL 2 and filed the DI tubing between the DI panel and the fuel cell. Disassembled the leaking flowmeter that was removed from the CHP loop and repaired.		
			Friday - put the fuel cell through a trial start-up. The stack is very sluggish, however, it did make it to 2.0kw. After a little runtime it should perform much better. I also successfully completed the anti-islanding test. I also repaired a damaged crimp fitting between the Heliodyne and the water heater.		
Worley	2/28/2005	277			
			1109610240,2/28/2005 12:04:00 PM, Manual (20)ALERT, PHONE_LINE1_BAD_MODEM_RESPONSE, Error Code: (120)(0)		
			1109610263,2/28/2005 12:04:23 PM, Manual (20)ALERT, PHONE_LINE2_BAD_MODEM_RESPONSE, Error Code: (128)(0)		
			1109610325,2/28/2005 12:05:25 PM, Manual (20)ALERT, PHONE_LINE2_TIMEOUT, Error Code: (124)(0)		
			1109610424,2/28/2005 12:07:04 PM, Manual (20)ALERT, PHONE_LINE1_TIMEOUT, Error Code: (116)(0)		
			1109610464,2/28/2005 12:07:44 PM, Manual (20)ALERT, PHONE_LINE1_BAD_MODEM_RESPONSE, Error Code: (120)(0)		
			1109610519,2/28/2005 12:08:39 PM, Manual (20)ALERT, PHONE_LINE2_BAD_MODEM_RESPONSE, Error Code: (128)(0)		
			1109610581,2/28/2005 12:09:41 PM, SD Ref Cool (104)ALERT, PHONE_LINE2_TIMEOUT, Error Code: (124)(0)		
			1109610632,2/28/2005 12:10:32 PM, ESTOP (107)ESTOP, HW_ESTOP_SARC_L0, Error Code: (534)(0)		

			1109611356,2/28/2005 12:22:36 PM, Manual (20)ALERT, PHONE_LINE1_PASSED, Error Code: (115)(0)		
			1109611404,2/28/2005 12:23:24 PM, Manual (20)ALERT, PHONE_LINE2_PASSED, Error Code: (123)(0)		
			1109612267,2/28/2005 12:37:47 Empower Down (200)ALERT, REMOTE_REQUESTED_ESTOP, Error Code: (601)(0)		
			1109614757,2/28/2005 1:19:17 PM, Reformer Purge (31)EVENT, STARTUP_EVENT, Error Code: (1000)(0)		
			1109628676,2/28/2005 5:11:16 PM, Unknown (100)ALERT, REMOTE_REQUESTED_SHUTDOWN, Error Code: (600)(0)		
			1109628677,2/28/2005 5:11:17 PM, SD Ref Cool (104)EVENT, SHUTDOWN_EVENT, Error Code: (1001)(0)		
			1109628835,2/28/2005 5:13:55 PM, Power Down (200)ALERT, REMOTE_REQUESTED_ESTOP, Error Code: (601)(0)		
			1109628946,2/28/2005 5:15:46 PM, Power Down (200)ALERT, REMOTE_REQUESTED_ESTOP, Error Code: (601)(0)		

LOGANEnergy Corp.					
Monthly Site Report					
Period	March-05				
Site	GA TECH				
Engineer	**Date**	**PP S/N**	**Activity**	**Mileage**	**Hours**
Worley	3/1/2005	277			
			1109698148,3/1/2005 12:29:08 PM, Reformer Purge (31)ESTOP, HW_ESTOP_FS7_PRES2_L3, Error Code: (529)(0)		
			1109698160,3/1/2005 12:29:20 PM, Reformer Purge (31)SHUTDOWN, LOSS_AIR_TSI_COMM, Error Code: (524)(0)		
			1109698160,3/1/2005 12:29:20 PM, SD Ref Cool (104)EVENT, SHUTDOWN_EVENT, Error Code: (1001)(0)		
			1109698181,3/1/2005 12:29:41 PM, SD Ref Cool (104)SHUTDOWN, LOSS_ATO_BLOWER, Error Code: (546)(0)		
			1109698541,3/1/2005 12:35:41 PM, Reformer Purge (31)EVENT, STARTUP_EVENT, Error Code: (1000)(0)		

			1109698572,3/1/2005 12:36:12 PM, Reformer Purge (31)ALERT, ABORT_DATA_TRANSFER, Error Code: (131)(0)		
			1109698939,3/1/2005 12:42:19 PM, SD Ref Cool (104)EVENT, SHUTDOWN_EVENT, Error Code: (1001)(0)		
			1109698951,3/1/2005 12:42:31 PM, ESTOP (107)ESTOP, HW_ESTOP_SARC_L0, Error Code: (534)(0)		
			1109698965,3/1/2005 12:42:45 PM, ESTOP (107)SHUTDOWN, LOSS_ATO_BLOWER, Error Code: (546)(0)		
			1109702990,3/1/2005 1:49:50 PM, Reformer Purge (31)EVENT, STARTUP_EVENT, Error Code: (1000)(0)		
			1109714189,3/1/2005 4:56:29 PM, Unknown (100)ALERT, REMOTE_REQUESTED_SHUTDOWN, Error Code: (600)(0)		
			1109714189,3/1/2005 4:56:29 PM, SD Ref Cool (104)EVENT, SHUTDOWN_EVENT, Error Code: (1001)(0)		
			1109714316,3/1/2005 4:58:36 PM, Power Down (200)ALERT, REMOTE_REQUESTED_ESTOP, Error Code: (601)(0)		
			1109722767,3/1/2005 7:19:27 PM, Reformer Purge (31)EVENT, STARTUP_EVENT, Error Code: (1000)(0)		
			1109723905,3/1/2005 7:38:25 PM, Reformer Warm-up (32)ALERT, I2C_GET_ANALOG_COMM, Error Code: (111)(-32768)		
			1109725477,3/1/2005 8:04:37 PM, Running Warm-up (50)ALERT, RECOVER_CATHODE_AIR_BLOWER, Error Code: (555)(0)		
			1109725615,3/1/2005 8:06:55 PM, Running Warm-up (50)SHUTDOWN, LOSS_CATHODE_AIR_BLOWER, Error Code: (538)(0)		
			1109725615,3/1/2005 8:06:55 PM, SD Ref Cool (104)EVENT, SHUTDOWN_EVENT, Error Code: (1001)(0)		
Worley	3/4/2005	277		627	32
			Monday - Re-installed batteries after charging them over the weekend. Test ran the fuel cell for operational issues.		
			Tuesday - Started fuel cell to verify operation prior to having GA Power on site. Fuel cell shut down due to Loss cathode air blower. I was able to restart the unit remotely.		
			Wednesday - Formal commissioning of the fuel cell. I met GA Power on site to go over the grid		

			interconnect. Jud Shumway, GA Power had no issues with the installation. Completed the anti-islanding test and the harmonics measurements. Left the unit running at 2.5 kW after a successful startup.		
			Thursday - The unit shutdown due to an issue with FS7. I suspect that someone might have held the OP Panel door open and restricted the airflow. I had Col. McCarthy restart the controller and restarted the fuel cell remotely.		
			Friday - I spent a good part of the day trying to identify a problem with the BTU readings displayed on the CE website. It seems that we have a bad RTD or flowmeter. I will return to the site for follow up.		
Worley	3/15/2005			75	4
			Troubleshoot startup circuit and e-stop loops. Could not get SARC to power up. Power circuits good up to SARC board. Drove to McPherson to get spare SARC board. Replaced.		

LOGANEnergy Corp.					
Monthly Site Report					
Period	June-05				
Site	GA TECH				
Engineer	**Date**	**PP S/N**	**Activity**	**Mileage**	**Hours**
Worley	6/1/2005	277		148	3
			Unplugged phone line and tested with RadioShack phone line tester (43-2225). Line checked good for polarity. Used regular telephone to verify phone line operation. Successfully called out to 1-800 number. Checked voltage on phone line 25.7V. Reconnected phone line. Had Plug Power verify that they could call in to system. Powered down SARC to reset communications. Restarted fuel cell.		
Worley	6/6/2005	277		157	4
			Reset modem by powering down SARC. Restarted fuel cell.		

LOGANEnergy Corp.					
Monthly Site Report					
Period	August-05				
Site	GA TECH				
Engineer	**Date**	**PP S/N**	**Activity**	**Mileage**	**Hours**
Worley	8/8/2005	277		154	3
			When I arrived on site the fuel cell SARC would not power up. I performed start circuit trouble shooting per Plug Power service manual. The start circuit checked out OK. Replaced SARC. Performed modem test (OK). Reloaded all system parameters with the exception of statistics. Used lifetime stats, from last visit (7/13/2005) Had Rob Lowen dial in to verify modem operational. Verified Connected		

			Energy operational. Fuel cell running as of 10:30pm.		

LOGANEnergy Corp.					
Monthly Site Report					
Period	November-05				
Site	GA TECH				
Engineer	**Date**	**PP S/N**	**Activity**	**Mileage**	**Hours**
Worley	11/29/2005	277		150	3
			I shut the unit down at 6:30am and headed to the site. Estopping a running unit captures moisture in the stack and sometimes helps re-hydrate the stack membranes. I arrived on site around 9:30am due to traffic. Replaced the desulfurizer. Replaced the DI polishing filter. Cleaned the air intake screens and replaced the blue filter at the SARC intake. The desulfurizer that I replaced has a minor propane leak at the clamp ring that holds the cover on. It is not enough to cause any problem, but it does register on the leak detector.		

LOGANEnergy Corp.					
Monthly Site Report					
Period	December-05				
Site	GA TECH				
Engineer	**Date**	**PP S/N**	**Activity**	**Mileage**	**Hours**
Worley	12/5/2005	277		187	6
			Drained stack coolant and replaced stack. Replaced leaking desulfurizer. Refilled stack coolant, adding about 2 quarts. Updated system parameters to reflect stack change out. Started fuel cell. While on site I also replaced the RO and particulate filters. Refilled the CHP loop to 30psi.		